The system discussed herein can produce and amplify the specified, discrete states in a simpler manner than using a single amplifier. The present system uses multiple amplifiers and radiators that are each driven into one of four discrete, specified states. Driving the multiple amplifiers into the four discrete, specified states avoids the upper and lower power level limitations of a single amplifier operating in the linear region, and can therefore produce more output power than the single, linear-driven amplifier.

The states from the multiple radiators all combine through far-field electromagnetic propagation, and effectively sum at the receiver to mimic transmission from a single amplifier. A standard receiver, with standard electronics, can receive the signal from the present system, and can decode the received signal in a known, standard manner.

The multiple radiators are driven in groups, with the radiators in each group being driven together. The number of radiators in the groups is selected so that the full range of amplitudes and phases can be achieved by the combined output of all the radiators. In some examples, there are three groups, which include one radiator, two radiators, and four radiators, respectively. In some other examples, there are four groups, which include one radiator, two radiators, four radiators, and eight radiators, respectively. In general, for m groups, the groups can have 2^0 radiators, 2^1 radiators, . . . , and 2^{m-1} radiators, respectively.

Each radiator can be driven to n states of amplitude and phase. In some examples, the radiators are driven using phase-shift keying (PSK) signals. In PSK signals, the amplitude is held constant, while the phase is set to one of a discrete, specified number of values. For n-PSK signals, the phase values are equally spaced, and are spaced apart by 360 degrees, divided by n. In some examples, the radiators are driven with 4-PSK signals, where each 4-PSK signal can take on one of four specified states that have the same amplitude and differ in phase by 90 degrees. In general, if m PSK signals are used, with each PSK signal being an n-PSK signal, the result is n^m-QAM, which has n^m discrete detectable states.

An advantage of using n-PSK signals, and specifically 4-PSK signals, is that an amplifier can use a constant amplitude, and vary only a phase to represent the data stream. Such an amplifier can be run in saturation, as opposed to in a linear regime, and can therefore achieve a greater power output and greater efficiency than a comparable amplifier driven in linearity.

There are potential advantages to generating n^m-QAM detection using m stages of n-PSK signals. A first advantage can be that the amplifiers are driven in saturation, which can be significantly easier than driving in a linear regime. A second advantage can be that the individual signals from the antennas are all combined as linearly superimposed fields in the far field, through electro-magnetic propagation though air. Such combination is relatively simple and lossless, and eliminates the need for an explicit, and potentially lossy, combiner, such as a resonant cavity or a transmission line circuit. A third advantage can be that eliminating an explicit combiner also eliminates the need to cool such a combiner. A fourth advantage can be that the present transmission scheme can reduce or eliminate interaction between or among amplifiers, which can occur in reactively combined amplifier arrays, such as resonant cavities. A fifth advantage can be that the present transmission scheme can be compatible with other modulation formats, such as amplitude modulation phase shift keying (AM/PSK) or multi-carrier, e.g., orthogonal frequency-division multiplexing (OFDM).

In practice, the system can include well-defined tolerances on quantities, such as signal amplitudes, signal phases, angles, and others. The tolerances allow for relatively small errors in the quantities that can occur during manufacture, assembly, calibration, and operation. These tolerances can allow the performance of particular components to vary slightly with respect to particular quantities, such as temperature, which can reduce the cost and/or complexity of the components. In a data transmission system where data integrity is essential, such as the present system, the tolerances are typically budgeted in a manner that ensures that during operation, each of the discrete, specified states will not be mistaken for any other of the discrete, specified states, even for extremes in the tolerance ranges. For the purposes of this document, the term approximately is intended to represent a target value, plus or minus an operational tolerance that is well-known to one of ordinary skill in the art.

FIG. **1** is a schematic drawing of an example of a system **100** for transmitting a quadrature amplitude modulation (64-QAM) waveform. The system **100** can include a local oscillator **102** driving a distribution amplifier **104**. The distribution amplifier **104** can direct signals through phase shifters **112**, **122**, **132**, and variable attenuators **114**, **124**, **134** to respective first, second, and third mixers **110**, **120**, and **130** as a common local oscillator signal.

The system **100** can include an encoder **106** that receives a stream of data as input. The stream of data is encoded by the system **100**, and is transmitted by the system **100** to a receiver at a remote location. The encoder **106** encodes the stream of data as three synchronized phase-shift keying (PSK) signals, namely a first PSK signal **118**, a second PSK signal **128**, and a third PSK signal **138**. The PSK signals **118**, **128**, and **138** pass through respective low-pass filters **116**, **126**, **136** to the respective first, second, and third mixers **110**, **120**, and **130**.

The first, second, and third mixers **110**, **120**, and **130** combine synchronized first, second, and third phase-shift keying (PSK) signals **118**, **128**, and **138** with the common local oscillator signal to form respective first, second, and third amplifiable signals **119**, **129**, and **139**.

A first amplifier **141** receives the first amplifiable signal **119** and powers a first radiator **151** in response to the received first amplifiable signal **119**. Second and third amplifiers **142**, **143** both receive the second amplifiable signal **129** and power respective second and third radiators **152**, **153** in response to the received second amplifiable signal **129**. Fourth, fifth, sixth, and seventh amplifiers **144**, **145**, **146**, **147** all receive the third amplifiable signal **139** and power respective fourth, fifth, sixth, and seventh radiators **154**, **155**, **156**, and **157** in response to the received third amplifiable signal **139**.

Each of the first, second, third, fourth, fifth, sixth, and seventh radiators **151**, **152**, **153**, **154**, **155**, **156**, and **157** radiates in one of a plurality of allowable discrete, specified states. For instance, the specified states can be represented as $Ae^{i\Phi}$, where A is a specified amplitude, and ϕ is a phase that can take on one of four discrete, specified values, such as 0 degrees, 90 degrees, 180 degrees, and 270 degrees, or 45 degrees, 135 degrees, 225 degrees, and 315 degrees. In some examples, the allowable radiated states are approximately the same for all of the radiators.

The radiated states from the first, second, third, fourth, fifth, sixth, and seventh radiators **151**, **152**, **153**, **154**, **155**, **156**, and **157** combine through far-field electromagnetic propagation and effectively sum at the receiver to mimic transmission from a single amplifier. For instance, four allowable states, combined through three groups of radiators, the three groups numbering one, two, and four radiators each, can produce 4^3, or 64 discrete, specified, detectable states at the receiver. Producing the 64 discrete states in this manner can generate higher transmitted powers than a comparable single